

CLAIMS:

1. A thermionic cathode doped with an increased binding energy hydrogen species.
2. A doped thermionic cathode according to claim 1, wherein said doped thermionic cathode having a voltage different from undoped cathode material.
3. A doped thermionic cathode according to claim 1, wherein said doped thermionic cathode having a voltage different from a cathode material doped with a dopant other than said increased binding energy hydrogen species.
4. A doped thermionic cathode according to claim 1, having a higher voltage than undoped cathode material.
5. A doped thermionic cathode according to claim 1, wherein undoped cathode material is a metal.
6. A doped thermionic cathode according to claim 1, wherein undoped cathode material comprises tungsten, molybdenum or an oxide thereof.
7. A doped thermionic cathode according to claim 1, wherein the increased binding energy hydrogen species comprises an increased binding energy hydride ion.
8. A doped thermionic cathode according to claim 1, wherein undoped cathode material has been doped with the increased binding energy hydrogen species by ion implantation, epitaxy, or vacuum deposition.
9. A doped thermionic cathode according to claim 1, wherein said increased binding hydrogen species comprises a hydrino atom having a desired energy level.
10. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species comprises at least one neutral, positive or negative increased binding energy hydrogen species having a binding energy:
 - (i) greater than the binding energy of the corresponding ordinary hydrogen species, or
 - (ii) greater than the binding energy of any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' binding energy is less than thermal energy of the ordinary hydrogen species at ambient conditions, or is negative.
11. A doped thermionic cathode according to claim 10, wherein said increased binding energy hydrogen species is selected from the group consisting of H_n , H_n^- , and H_n^+ , where n is an integer of 1 to 8, and n is greater than 1 when H has a

positive charge.

12. A doped thermionic cathode according to claim 10, wherein said increased binding energy hydrogen species comprises at least one other element selected from the group consisting of a proton, ordinary hydride ion, ordinary hydrogen atom, ordinary hydrogen molecules, ordinary hydrogen molecular ions and ordinary H_3^+ .
13. A doped thermionic cathode according to claim 10, wherein said increased binding energy hydrogen species comprises at least one other element selected from the group consisting of alkaline earth metals and alkali metals.
14. A doped thermionic cathode according to claim 10, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of organic compounds.
15. A doped thermionic cathode according to claim 10, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of semiconductors.
16. A doped thermionic cathode according to claim 1, wherein said increased binding hydrogen species is selected from the group consisting of (a) a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for $p = 2$ up to 23 in which the binding energy is represented by

$$Binding\ Energy = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left(1 + \left[\frac{2^2}{1 + \sqrt{s(s+1)}} \right]^3 \right)$$

where p is an integer greater than 1, $s = \frac{1}{2}$, \hbar is Plank's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge; (b) hydrogen atom having a binding energy greater than about 13.6 eV; (c) hydrogen molecule having a first binding energy greater than about 15.5 eV; and (d) molecular hydrogen ion having a binding energy greater than about 16.4 eV.

17. A doped thermionic cathode according to claim 1, wherein the increased binding energy species is hydride ion having a binding energy of about 3.0, 6.6, 11.2, 16.7, 22.8, 29.3, 36.1, 42.8, 49.4, 55.5, 61.0, 65.6, 69.2, 71.53, 72.4, 71.54, 68.8,

64.0, 56.8, 47.1, 34.6, or 19.2.

18. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species is a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for $p = 2$ up to 23 in which the binding energy is represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left(1 + \frac{2^2}{\left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1, $s = \frac{1}{2}$, \hbar is Plank's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge.

19. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species is selected from the group consisting of (a) a hydrino atom having a binding energy of about $13.6 \text{ eV}/(1/p)^2$, where p is an integer greater than 1; (b) a hydride ion having a binding energy represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left(1 + \frac{2^2}{\left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1, $s = \frac{1}{2}$, \hbar is Plank's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge; (c) a trihydrino molecular ion, $\text{H}_3^+ (1/p)$, having a binding energy of about $22.6/(1/p)^2 \text{ eV}$; (d) an increased binding energy hydrogen molecule having a binding energy of about $15.5/(1/p)^2 \text{ eV}$; and (e) an increased binding energy hydrogen molecular ion with a binding energy of about $16.4/(1/p)^2 \text{ eV}$.

20. A doped thermionic cathode according to claim 19, wherein p is 2 to 200.

21. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species has a negative charge.

64.0, 56.8, 47.1, 34.6, or 19.2.

18. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species is a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for $p = 2$ up to 23 in which the binding energy is represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left(1 + \frac{2^2}{\left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1, $s = \frac{1}{2}$, \hbar is Plank's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge.

19. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species is selected from the group consisting of (a) a hydrino atom having a binding energy of about $13.6 \text{ eV}/(1/p)^2$, where p is an integer greater than 1; (b) a hydride ion having a binding energy represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi\mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left(1 + \frac{2^2}{\left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1, $s = \frac{1}{2}$, \hbar is Plank's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge; (c) a trihydrino molecular ion, $\text{H}_3^+ (1/p)$, having a binding energy of about $22.6/(1/p)^2 \text{ eV}$; (d) an increased binding energy hydrogen molecule having a binding energy of about $15.5/(1/p)^2 \text{ eV}$; and (e) an increased binding energy hydrogen molecular ion with a binding energy of about $16.4/(1/p)^2 \text{ eV}$.

20. A doped thermionic cathode according to claim 19, wherein p is 2 to 200.

21. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species is negative.

22. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species further comprises at least one cation.
23. A doped thermionic cathode according to claim 22, wherein said cation is a proton, H_2^+ or H_3^+ .
24. A doped thermionic cathode according to claim 1, wherein said at least one increased binding energy hydrogen species having an observed characteristic different from that of the corresponding ordinary compound wherein the hydrogen content is only ordinary hydrogen, said observed characteristic being dependent on the increased binding energy hydrogen species.
25. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydride ion having a binding energy greater than 0.8 eV.
26. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydrogen atom having a binding energy of about $13.6/n^2$ eV, wherein n is a fraction whose numerator is 1 and denominator is an integer greater than 1.
27. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydrogen molecule having a first binding energy of about $15.5/n^2$ eV, wherein n is a fraction whose numerator is 1 and denominator is an integer greater than 1.
28. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species comprising at least one increased binding energy molecular hydrogen ion having a first binding energy of about $16.4/n^2$ eV, wherein n is a fraction whose numerator is 1 and denominator is an integer greater than 1.
29. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species comprising at least one hydride ion having a binding energy of about 0.65 eV.
30. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species comprising at least one hydride ion formulated from at least one hydrino atom.
31. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species comprising H_3^+ increased binding energy hydrogen species.

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32. A doped thermionic cathode according to claim 1, wherein said increased binding energy hydrogen species further comprises at least one other element.
33. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises at least one selected from the group consisting of ions and compounds containing an increased binding energy species.
34. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises one or more normal hydrogen atoms.
35. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises at least one selected from the group consisting of a proton, ordinary hydrogen atom, ordinary hydrogen molecules, ordinary hydrogen molecular ions, ordinary hydride ions, and ordinary H_3^+ .
36. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises at least one element selected from the group consisting of alkaline earth metals and alkali metals.
37. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises at least one element selected from the group consisting of organic compounds.
38. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises at least one element selected from the group consisting of semiconductors.
39. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises a refractory metal.
40. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises a metal.
41. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises an electrical conductor.
42. A doped thermionic cathode according to claim 32, wherein said at least one other element comprises a source of thermal electrons.
43. A doped thermionic cathode according to claim 32, wherein said thermionic cathode is doped with a dopant comprising said increased binding energy hydrogen species.
44. A doped thermionic cathode according to claim 43, wherein the dopant has the formula selected from the group of formulae consisting of MH , MH_2 , and M_2H_2 .

wherein M is an alkali cation and H is selected from the group consisting of increased binding energy hydride ions, hydrino atoms and dihydrino molecules.

45. A doped thermionic cathode according to claim 43, wherein the dopant has the formula MH_n wherein n is 1 or 2, M is an alkaline earth cation and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
46. A doped thermionic cathode according to claim 43, wherein the dopant has the formula MHX wherein M is an alkali cation, X is one of a neutral atom, a molecule, or a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
47. A doped thermionic cathode according to claim 46, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
48. A doped thermionic cathode according to claim 43, wherein the dopant has the formula MHX wherein M is an alkaline earth cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
49. A doped thermionic cathode according to claim 48, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
50. A doped thermionic cathode according to claim 43, wherein the dopant has the formula MHX wherein M is an alkaline earth cation, X is a doubly negatively charged anion, and H is a hydrino atom.
51. A doped thermionic cathode according to claim 43, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
52. A doped thermionic cathode according to claim 43, wherein the dopant has the formula M_2HX wherein M is an alkali cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
53. A doped thermionic cathode according to claim 52, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
54. A doped thermionic cathode according to claim 43, wherein the dopant has the formula MH_n wherein n is an integer from 1 to 5, M is an alkali cation and the

hydrogen content H_n comprises at least one increased binding energy hydrogen species.

55. A doped thermionic cathode according to claim 43, wherein the dopant has the formula M_2H_n wherein n is an integer from 1 to 4, M is an alkaline earth cation and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
56. A doped thermionic cathode according to claim 43, wherein the dopant has the formula M_2XH_n wherein n is an integer from 1 to 3, M is an alkaline earth cation, X is a singly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
57. A doped thermionic cathode according to claim 56, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
58. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $M_2X_2H_n$ wherein n is 1 or 2, M is an alkaline earth cation, X is a singly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
59. A doped thermionic cathode according to claim 58, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
60. A doped thermionic cathode according to claim 43, wherein the dopant has the formula M_2X_3H wherein M is an alkaline earth cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrido atoms.
61. A doped thermionic cathode according to claim 60, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
62. A doped thermionic cathode according to claim 43, wherein the dopant has the formula M_2XH_n wherein n is 1 or 2, M is an alkaline earth cation, X is a doubly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
63. A doped thermionic cathode according to claim 62, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
64. A doped thermionic cathode according to claim 43, wherein the dopant has the

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formula $M_2XX'H$ wherein M is an alkaline earth cation, X is a singly negatively charged anion, X' is a doubly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.

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- 65. A doped thermionic cathode according to claim 65, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
- 66. A doped thermionic cathode according to claim 65, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
- 67. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MM'H_n$ wherein n is an integer from 1 to 3, M is an alkaline earth cation, M' is an alkali metal cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
- 68. A doped thermionic cathode according to claim 43, wherein the dopant is $MM'XH_n$ wherein n is 1 to 2, M is an alkaline earth cation, M' is an alkali metal cation, X is a singly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
- 69. A doped thermionic cathode according to claim 68, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
- 70. A doped thermionic cathode according to claim 43, wherein the dopant is $MM'XH$ where M is an alkaline earth cation, M' is an alkali metal cation, X is a doubly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
- 71. A doped thermionic cathode according to claim 70, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
- 72. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MM'XX'H$ where M is an alkaline earth cation, M' is an alkali metal cation, X and X' are each a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
- 73. A doped thermionic cathode according to claim 72, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

74. A doped thermionic cathode according to claim 43, wherein the dopant has the formula H_nS wherein n is 1 or 2, and the hydrogen content of H_n comprises at least one increased binding energy hydrogen species.

75. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MSiH_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content of H_n comprises at least one increased binding energy hydrogen species.

76. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MXM'H_n$ wherein

- n is an integer from 1 to 5;
- M is an alkali or alkaline earth cation;
- X is a singly negatively charged anion or a doubly negatively charged anion;
- M' is selected from the group consisting of Si, Al, Ni, the transition elements, the inner transition elements, and the rare earth elements; and
- the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

77. A doped thermionic cathode according to claim 76, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.

78. A doped thermionic cathode according to claim 76, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

79. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MAIH_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

80. A doped thermionic cathode according to claim 43, wherein the dopant has the formula MH_n wherein:

- n is an integer from 1 to 6;
- M is selected from the group consisting of the transition elements, the inner transition elements, and the rare earth element cations and nickel; and
- the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

81. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MNiH_n$ wherein:

- n is an integer from 1 to 6;

M is selected from the group consisting of alkali cations, alkaline earth cations, silicon, and aluminum; and
the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

82. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MM'H_n$ wherein:
n is an integer from 1 to 6;
M is selected from the group consisting of alkali cations, alkaline earth cations, silicon, and aluminum;
M' is selected from the group consisting of the transition elements, the inner transition elements, and rare earth element cations; and
the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

83. A doped thermionic cathode according to claim 43, wherein the dopant has the formula M_2SiH_n wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

84. A doped thermionic cathode according to claim 43, wherein the dopant has the formula Si_2H_n wherein n is an integer from 1 to 8, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

85. A doped thermionic cathode according to claim 43, wherein the dopant has the formula SiH_n wherein n is an integer from 1 to 8, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

86. A doped thermionic cathode according to claim 43, wherein the dopant has the formula TiH_n wherein n is an integer from 1 to 4, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

87. A doped thermionic cathode according to claim 43, wherein the dopant has the formula Al_2H_n wherein n is an integer from 1 to 4 and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

88. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MXAIX'H_n$ wherein n is 1 or 2, M is an alkali or alkaline earth cation, X and X' are each either a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

89. A doped thermionic cathode according to claim 88, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.

90. A doped thermionic cathode according to claim 88, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

91. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MXSiX'H_n$ wherein n is 1 or 2, M is an alkali or alkaline earth cation, X and X' are each either a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

92. A doped thermionic cathode according to claim 91, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.

93. A doped thermionic cathode according to claim 91, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

94. A doped thermionic cathode according to claim 43, wherein the dopant has the formula SiO_2H_n wherein n is an integer from 1 to 6 and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

95. A doped thermionic cathode according to claim 43, wherein the dopant has the formula $MSiO_2H_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

96. A doped thermionic cathode according to claim 43, wherein the dopant has the formula MSi_2H_n wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

97. A doped thermionic cathode according to claim 43, wherein the dopant has the formula M_2SiH_n wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

98. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $[KH_mKCO_3]_n$ wherein m and n are each an integer and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.

99. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $[KH_mKNO_3]_n^+ nX^-$ wherein m and n are each an integer, X is a singly

negatively charged anion, and the hydrogen content of H_m of the dopant comprises at least one increased binding energy hydrogen species.

100. A doped thermionic cathode according to claim 99, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
101. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $[KHNO_3]_n$, wherein n is an integer and the hydrogen content H of the dopant comprises at least one said binding energy hydrogen species.
102. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $[KHKOH]_n$ wherein n is an integer and the hydrogen content H of the dopant comprises at least one said binding energy hydrogen species.
103. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $[MH_mM'X]_n$, wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X is a singly or doubly negatively charged anion, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
104. A doped thermionic cathode according to claim 103, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
105. A doped thermionic cathode according to claim 103, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.
106. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $[MH_mM'X]_n^+ nX^-$ wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X and X' are a singly or doubly negatively charged anion, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
107. A doped thermionic cathode according to claim 106, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
108. A doped thermionic cathode according to claim 106, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.
109. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $MXSiX'H_n$ wherein n is 1 or 2, M is an alkali or alkaline earth cation, X

and X' are with a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

110. A doped thermionic cathode according to claim 109, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
111. A doped thermionic cathode according to claim 109, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.
112. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $MSiH_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.
113. A doped thermionic cathode according to claim 43, wherein said dopant having a formula Si_nH_{4n} wherein n is an integer and the hydrogen content H_{4n} of the dopant comprises at least one increased binding energy hydrogen species.
114. A doped thermionic cathode according to claim 43, wherein said dopant having a formula Si_nH_{3n} wherein n is an integer and the hydrogen content H_{3n} of the dopant comprises at least one increased binding energy hydrogen species.
115. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $Si_nH_{3n}O_m$ wherein n and m are integers and the hydrogen content H_{3n} of the dopant comprises at least one increased binding energy hydrogen species.
116. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $Si_xH_{4x-2y}O_y$ wherein x and y are each an integer and the hydrogen content H_{4x-2y} of the dopant comprises at least one increased binding energy hydrogen species.
117. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $Si_xH_{4x}O_y$ wherein x and y are each an integer and the hydrogen content H_{4x} of the dopant comprises at least one increased binding energy hydrogen species.
118. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $Si_nH_{4n}H_2O$ wherein n is an integer and the hydrogen content H_{4n} of the dopant comprises at least one increased binding energy hydrogen species.
119. A doped thermionic cathode according to claim 43, wherein said dopant having a formula Si_nH_{2n+2} wherein n is an integer and the hydrogen content H_{2n+2} of the

dopant comprises at least one increased binding energy hydrogen species.

120. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $Si_xH_{2x+2}O_y$ wherein x and y are each an integer and the hydrogen content H_{2x+2} of the dopant comprises at least one increased binding energy hydrogen species.
121. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $Si_nH_{4n-2}O$ wherein n is an integer and the hydrogen content H_{4n-2} of the dopant comprises at least one increased binding energy hydrogen species.
122. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $MSi_{4n}H_{10n}O_n$ wherein n is an integer, M is an alkali or alkaline earth cation, and the hydrogen content H_{10n} of the dopant comprises at least one increased binding energy hydrogen species.
123. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $MSi_{4n}H_{10n}O_{n+1}$ wherein n is an integer, M is an alkali or alkaline earth cation, and the hydrogen content H_{10n} of the dopant comprises at least one increased binding energy hydrogen species.
124. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $M_qSi_nH_mO_p$ wherein q, n, m, and p are integers, M is an alkali or alkaline earth cation, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
125. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $M_qSi_nH_m$ wherein q, n, and m are integers, M is an alkali or alkaline earth cation, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
126. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $Si_nH_mO_p$ wherein n, m, and p are integers, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
127. A doped thermionic cathode according to claim 43, wherein said dopant having a formula Si_nH_m wherein n and m are integers, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
128. A doped thermionic cathode according to claim 43, wherein said dopant having a formula $MSiH_n$ wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

129. A doped thermionic cathode according to claim 43, wherein said dopant having a formula Si_2H_n wherein n is an integer from 1 to 8, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

130. A doped thermionic cathode according to claim 43, wherein said dopant having a formula SiH_n wherein n is an integer from 1 to 8, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

131. A doped thermionic cathode according to claim 43, wherein said dopant having a formula SiO_2H_n wherein n is an integer from 1 to 6, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

132. A doped thermionic cathode according to claim 43, wherein said dopant having a formula MSiO_2H_n wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

133. A doped thermionic cathode according to claim 43, wherein said dopant having a formula MSi_2H_n wherein n is an integer from 1 to 14, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

134. A doped thermionic cathode according to claim 43, wherein said dopant having a formula M_2SiH_n wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

135. A method of making a doped thermionic cathode comprising;
providing a cathode material; and
doping said cathode material with an increased binding energy hydrogen species to form said doped thermionic cathode.

136. A method according to claim 135, wherein said cathode material is doped using ion implantation.

137. A method according to claim 135, wherein said cathode material is doped using epitaxy.

138. A method according to claim 135, wherein said cathode material is doped using vacuum deposition.

139. A method according to claim 135, wherein said doped thermionic cathode having a voltage different from said cathode material.

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140. A method according to claim 135, wherein said doped thermionic cathode having a voltage different from a cathode material doped with a dopant other than said increased binding energy hydrogen species.

141. A method according to claim 135, wherein said doped cathode having a higher voltage than said cathode material.

142. A method according to claim 135, wherein said cathode material is a metal.

143. A method according to claim 135, wherein said cathode material comprises tungsten, molybdenum or an oxide thereof.

144. A method according to claim 135, wherein the increased binding energy hydrogen species comprises an increased binding energy hydride ion.

145. A method according to claim 135, wherein said cathode material has been doped with the increased binding energy hydrogen species by ion implantation, epitaxy, or vacuum deposition.

146. A method according to claim 135, wherein said increased binding hydrogen species comprises a hydrino atom having a desired energy level.

147. A method according to claim 135, wherein said increased binding energy hydrogen species comprises at least one neutral, positive or negative increased binding energy hydrogen species having a binding energy:
(i) greater than the binding energy of the corresponding ordinary hydrogen species, or
(ii) greater than the binding energy of any hydrogen species for which the corresponding ordinary hydrogen species is unstable or is not observed because the ordinary hydrogen species' binding energy is less than thermal energy of the ordinary hydrogen species at ambient conditions, or is negative.

148. A method according to claim 148, wherein said increased binding energy hydrogen species is selected from the group consisting of H_n , H_n^- , and H_n^+ , where n is an integer of 1 to 8, and n is greater than 1 when H has a positive charge.

149. A method according to claim 148, wherein said increased binding energy hydrogen species comprises at least one selected from the group consisting of a proton, ordinary hydride ion, ordinary hydrogen atom, ordinary hydrogen molecules, ordinary hydrogen molecular ions and ordinary H_3^+ .

150. A method according to claim 148, wherein said increased binding energy

hydrogen species comprises at least one element selected from the group consisting of alkaline earth metals and alkali metals.

151. A method according to claim 148, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of organic compounds.
152. A method according to claim 148, wherein said increased binding energy hydrogen species comprises at least one element selected from the group consisting of semiconductors.
153. A method according to claim 135, wherein said increased binding hydrogen species is selected from the group consisting of (a) a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for $p = 2$ up to 23 in which the binding energy is represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi \mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left(1 + \frac{2^2}{\left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1, $s = \frac{1}{2}$, \hbar is Plank's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge; (b) hydrogen atom having a binding energy greater than about 13.6 eV; (c) hydrogen molecule having a first binding energy greater than about 15.5 eV; and (d) molecular hydrogen ion having a binding energy greater than about 16.4 eV.

154. A method according to claim 135, wherein the increased binding energy species is hydride ion having a binding energy of about 3.0, 6.6, 11.2, 16.7, 22.8 29.3, 36.1, 42.8, 49.4, 55.5, 61.0, 65.6, 69.2, 71.53, 72.4, 71.54, 68.8, 64.0, 56.8, 47.1, 34.6, or 19.2.
155. A method according to claim 135, wherein said increased binding energy hydrogen species is a hydride ion having a binding energy greater than the binding energy of the corresponding ordinary hydride ion for $p = 2$ up to 23 in which the binding energy is represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi \mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left(1 + \frac{2^2}{\left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1, $s = \frac{1}{2}$, \hbar is Plank's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge.

156. A method according to claim 135, wherein said increased binding energy hydrogen species is selected from the group consisting of (a) a hydrino atom having a binding energy of about $13.6 \text{ eV}/(1/p)^2$, where p is an integer greater than 1; (b) a hydride ion having a binding energy represented by

$$\text{Binding Energy} = \frac{\hbar^2 \sqrt{s(s+1)}}{8\mu_e a_0^2 \left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^2} - \frac{\pi \mu_0 e^2 \hbar^2}{m_e^2 a_0^3} \left(1 + \frac{2^2}{\left[\frac{1 + \sqrt{s(s+1)}}{p} \right]^3} \right)$$

where p is an integer greater than 1, $s = \frac{1}{2}$, \hbar is Plank's constant bar, μ_0 is the permeability of vacuum, m_e is the mass of the electron, μ_e is the reduced electron mass, a_0 is the Bohr radius, and e is the elementary charge; (c) a trihydrino molecular ion, $\text{H}_3^+ (1/p)$, having a binding energy of about $22.6/(1/p)^2 \text{ eV}$; (d) an increased binding energy hydrogen molecule having a binding energy of about $15.5/(1/p)^2 \text{ eV}$; and (e) an increased binding energy hydrogen molecular ion with a binding energy of about $16.4/(1/p)^2 \text{ eV}$.

157. A method according to claim 156, wherein p is 2 to 200.

158. A method according to claim 135, wherein said increased binding energy hydrogen species has a negative charge.

159. A method according to claim 135, wherein said increased binding energy hydrogen species further comprises at least one cation.

160. A method according to claim 159, wherein said cation is a proton, H_2^+ or H_3^+ .

161. A method according to claim 135, wherein said at least one increased binding energy hydrogen species having an observed characteristic different from that of the corresponding ordinary compound wherein the hydrogen content is only

ordinary hydrogen, said observed characteristic being dependent on the increased binding energy hydrogen species.

162. A method according to claim 135, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydride ion having a binding energy greater than 0.8 eV.
163. A method according to claim 135, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydrogen atom having a binding energy of about $13.6/n^2$ eV, wherein n is a fraction whose numerator is 1 and denominator is an integer greater than 1.
164. A method according to claim 135, wherein said increased binding energy hydrogen species comprising at least one increased binding energy hydrogen molecule having a first binding energy of about $15.5/n^2$ eV, wherein n is a fraction whose numerator is 1 and denominator is an integer greater than 1.
165. A method according to claim 135, wherein said increased binding energy hydrogen species comprising at least one increased binding energy molecular hydrogen ion having a first binding energy of about $16.4/n^2$ eV, wherein n is a fraction whose numerator is 1 and denominator is an integer greater than 1.
166. A method according to claim 135, wherein said increased binding energy hydrogen species comprising at least one hydride ion having a binding energy of about 0.65 eV.
167. A method according to claim 135, wherein said increased binding energy hydrogen species comprising at least one hydride ion formulated from at least one hydrino atom.
168. A method according to claim 135, wherein said increased binding energy hydrogen species comprising H_3^+ increased binding energy hydrogen species.
169. A method according to claim 135, wherein said increased binding energy hydrogen species further comprises at least one other element.
170. A method according to claim 169, wherein said at least one other element comprises at least one selected from the group consisting of ions and compounds containing an increased binding energy species.
171. A method according to claim 169, wherein said at least one other element comprises one or more normal hydrogen atoms.
172. A method according to claim 169, wherein said at least one other element

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comprises at least one selected from the group consisting of a proton, ordinary hydrogen atom, ordinary hydrogen molecules, ordinary hydrogen molecular ions, ordinary hydride ions, and ordinary H_3^+ .

173. A method according to claim 169, wherein said at least one other element comprises at least one element selected from the group consisting of alkaline earth metals and alkali metals.
174. A method according to claim 169, wherein said at least one other element comprises at least one element selected from the group consisting of organic compounds.
175. A method according to claim 169, wherein said at least one other element comprises at least one element selected from the group consisting of semiconductors.
176. A method according to claim 169, wherein said at least one other element comprises a refractory metal.
177. A doped thermionic cathode according to claim 169, wherein said at least one other element comprises a metal.
178. A doped thermionic cathode according to claim 169, wherein said at least one other element comprises an electrical conductor.
179. A doped thermionic cathode according to claim 169, wherein said at least one other element comprises a source of thermal electrons.
180. A method according to claim 169, wherein said thermionic cathode is doped with a dopant comprising said increased binding energy hydrogen species.
181. A method according to claim 180, wherein the dopant has the formula selected from the group of formulae consisting of MH , MH_2 , and M_2H_2 wherein M is an alkali cation and H is selected from the group consisting of increased binding energy hydride ions, hydrino atoms and dihydrino molecules.
182. A method according to claim 180, wherein the dopant has the formula MH_n wherein n is 1 or 2, M is an alkaline earth cation and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
183. A method according to claim 180, wherein the dopant has the formula MHX wherein M is an alkali cation, X is one of a neutral atom, a molecule, or a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.

184. A method according to claim 183, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

185. A method according to claim 180, wherein the dopant has the formula MHX wherein M is an alkaline earth cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.

186. A method according to claim 185, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

187. A method according to claim 180, wherein the dopant has the formula MHX wherein M is an alkaline earth cation, X is a doubly negatively charged anion, and H is a hydrino atom.

188. A method according to claim 187, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.

189. A method according to claim 180, wherein the dopant has the formula M_2HX wherein M is an alkali cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.

190. A method according to claim 189, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

191. A method according to claim 180, wherein the dopant has the formula MH_n wherein n is an integer from 1 to 5, M is an alkali cation and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

192. A method according to claim 180, wherein the dopant has the formula M_2H_n wherein n is an integer from 1 to 4, M is an alkaline earth cation and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

193. A method according to claim 180, wherein the dopant has the formula M_2XH_n wherein n is an integer from 1 to 3, M is an alkaline earth cation, X is a singly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

194. A method according to claim 193, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen

carbonate ions, and nitrate ions.

195. A method according to claim 180, wherein the dopant has the formula $M_2X_2H_n$ wherein n is 1 or 2, M is an alkaline earth cation, X is a singly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
196. A method according to claim 195, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
197. A method according to claim 180, wherein the dopant has the formula M_2X_3H wherein M is an alkaline earth cation, X is a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
198. A method according to claim 197, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
199. A method according to claim 180, wherein the dopant has the formula M_2XH_n wherein n is 1 or 2, M is an alkaline earth cation, X is a doubly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
200. A method according to claim 199, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
201. A method according to claim 180, wherein the dopant has the formula $M_2XX'H$ wherein M is an alkaline earth cation, X is a singly negatively charged anion, X' is a doubly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.
202. A method according to claim 201, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
203. A method according to claim 201, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
204. A method according to claim 180, wherein the dopant has the formula $MM'H_n$ wherein n is an integer from 1 to 3, M is an alkaline earth cation, M' is an alkali metal cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

205. A method according to claim 180, wherein the dopant is $MM'XH_n$ wherein n is 1 to 2, M is an alkaline earth cation, M' is an alkali metal cation, X is a singly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

206. A method according to claim 205, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

207. A method according to claim 180, wherein the dopant is $MM'XH$ where M is an alkaline earth cation, M' is an alkali metal cation, X is a doubly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.

208. A method according to claim 207, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.

209. A method according to claim 180, wherein the dopant has the formula $MM'XX'H$ where M is an alkaline earth cation, M' is an alkali metal cation, X and X' are each a singly negatively charged anion, and H is selected from the group consisting of increased binding energy hydride ions and hydrino atoms.

210. A method according to claim 209, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

211. A method according to claim 180, wherein the dopant has the formula H_nS wherein n is 1 or 2, and the hydrogen content of H_n comprises at least one increased binding energy hydrogen species.

212. A method according to claim 180, wherein the dopant has the formula $MSiH_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content of H_n comprises at least one increased binding energy hydrogen species.

213. A method according to claim 180, wherein the dopant has the formula $MXM'H_n$ wherein
n is an integer from 1 to 5;
M is an alkali or alkaline earth cation;
X is a singly negatively charged anion or a doubly negatively charged anion;
M' is selected from the group consisting of Si, Al, Ni, the transition elements, the inner transition elements, and the rare earth elements; and
the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

214. A method according to claim 213, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.

215. A method according to claim 213, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.

216. A method according to claim 180, wherein the dopant has the formula $MAIH_n$, wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

217. A method according to claim 180, wherein the dopant has the formula MH_n wherein:
n is an integer from 1 to 6;
M is selected from the group consisting of the transition elements, the inner transition elements, and the rare earth element cations and nickel; and
the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

218. A method according to claim 180, wherein the dopant has the formula $MNiH_n$ wherein:
n is an integer from 1 to 6;
M is selected from the group consisting of alkali cations, alkaline earth cations, silicon, and aluminum; and
the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

219. A method according to claim 180, wherein the dopant has the formula $MM'H_n$ wherein:
n is an integer from 1 to 6;
M is selected from the group consisting of alkali cations, alkaline earth cations, silicon, and aluminum;
M' is selected from the group consisting of the transition elements, the inner transition elements, and rare earth element cations; and
the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

220. A method according to claim 180, wherein the dopant has the formula M_2SiH_n wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

221. A method according to claim 180, wherein the dopant has the formula Si_2H_n wherein n is an integer from 1 to 8, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

least one increased binding energy hydrogen species.

- 222. A method according to claim 180, wherein the dopant has the formula SiH_n wherein n is an integer from 1 to 8, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
- 223. A method according to claim 180, wherein the dopant has the formula TiH_n wherein n is an integer from 1 to 4, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
- 224. A method according to claim 180, wherein the dopant has the formula Al_2H_n wherein n is an integer from 1 to 4 and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
- 225. A method according to claim 180, wherein the dopant has the formula $\text{MXAIX}'\text{H}_n$ wherein n is 1 or 2, M is an alkali or alkaline earth cation, X and X' are each either a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
- 226. A method according to claim 225, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
- 227. A method according to claim 225, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
- 228. A method according to claim 180, wherein the dopant has the formula $\text{MXSiX}'\text{H}_n$ wherein n is 1 or 2, M is an alkali or alkaline earth cation, X and X' are each either a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
- 229. A method according to claim 228, wherein said doubly negatively charged anion is selected from the group consisting of carbonate ions and sulfate ions.
- 230. A method according to claim 228, wherein said singly negatively charged anion is selected from the group consisting of halogen ions, hydroxide ions, hydrogen carbonate ions, and nitrate ions.
- 231. A method according to claim 180, wherein the dopant has the formula SiO_2H_n wherein n is an integer from 1 to 6 and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
- 232. A method according to claim 180, wherein the dopant has the formula MSiO_2H_n

wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.

233. A method according to claim 180, wherein the dopant has the formula MSi_2H_n wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
234. A method according to claim 180, wherein the dopant has the formula M_2SiH_n wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content H_n comprises at least one increased binding energy hydrogen species.
235. A method according to claim 180, wherein said dopant having a formula $[KH_mKCO_3]_n$ wherein m and n are each an integer and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
236. A method according to claim 180, wherein said dopant having a formula $[KH_mKNO_3]_n^+ nX^-$ wherein m and n are each an integer, X is a singly negatively charged anion, and the hydrogen content of H_m of the dopant comprises at least one increased binding energy hydrogen species.
237. A method according to claim 236, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.
238. A method according to claim 180, wherein said dopant having a formula $[KHKNO_3]_n$ wherein n is an integer and the hydrogen content H of the dopant comprises at least one said binding energy hydrogen species.
239. A method according to claim 180, wherein said dopant having a formula $[KHKOH]_n$ wherein n is an integer and the hydrogen content H of the dopant comprises at least one said binding energy hydrogen species.
240. A method according to claim 180, wherein said dopant having a formula $[MH_mM'X]_n$ wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X is a singly or doubly negatively charged anion, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
241. A method according to claim 240, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.

242. A method according to claim 240, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.

243. A method according to claim 180, wherein said dopant having a formula $[MH_mM'X]^+ nX^-$ wherein m and n are each an integer, M and M' are each an alkali or alkaline earth cation, X and X' are a singly or doubly negatively charged anion, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.

244. A method according to claim 243, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.

245. A method according to claim 243, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.

246. A method according to claim 180, wherein said dopant having a formula $MXSiX'H_n$ wherein n is 1 or 2, M is an alkali or alkaline earth cation, X and X' are with a singly negatively charged anion or a doubly negatively charged anion, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

247. A method according to claim 246, wherein said singly negatively charged anion is selected from the group consisting of halogen ion, hydroxide ion, hydrogen carbonate ion, and nitrate ion.

248. A method according to claim 246, wherein said doubly negative charged anion is selected from the group consisting of carbonate ion, oxide, and sulfate ion.

249. A method according to claim 180, wherein said dopant having a formula $MSiH_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

250. A method according to claim 180, wherein said dopant having a formula Si_nH_{4n} wherein n is an integer and the hydrogen content H_{4n} of the dopant comprises at least one increased binding energy hydrogen species.

251. A method according to claim 180, wherein said dopant having a formula Si_nH_{3n} wherein n is an integer and the hydrogen content H_{3n} of the dopant comprises at least one increased binding energy hydrogen species.

252. A method according to claim 180, wherein said dopant having a formula $Si_nH_{3n}O_m$ wherein n and m are integers and the hydrogen content H_{3n} of the

dopant comprises at least one increased binding energy hydrogen species.

253. A method according to claim 180, wherein said dopant having a formula $Si_xH_{4x-2y}O_y$ wherein x and y are each an integer and the hydrogen content H_{4x-2y} of the dopant comprises at least one increased binding energy hydrogen species.
254. A method according to claim 180, wherein said dopant having a formula $Si_xH_{4x}O_y$ wherein x and y are each an integer and the hydrogen content H_{4x} of the dopant comprises at least one increased binding energy hydrogen species.
255. A method according to claim 180, wherein said dopant having a formula $Si_nH_{4n}H_2O$ wherein n is an integer and the hydrogen content H_{4n} of the dopant comprises at least one increased binding energy hydrogen species.
256. A method according to claim 180, wherein said dopant having a formula Si_nH_{2n+2} wherein n is an integer and the hydrogen content H_{2n+2} of the dopant comprises at least one increased binding energy hydrogen species.
257. A method according to claim 180, wherein said dopant having a formula $Si_xH_{2x+2}O_y$ wherein x and y are each an integer and the hydrogen content H_{2x+2} of the dopant comprises at least one increased binding energy hydrogen species.
258. A method according to claim 180, wherein said dopant having a formula $Si_nH_{4n-2}O$ wherein n is an integer and the hydrogen content H_{4n-2} of the dopant comprises at least one increased binding energy hydrogen species.
259. A method according to claim 180, wherein said dopant having a formula $MSi_{4n}H_{10n}O_n$ wherein n is an integer, M is an alkali or alkaline earth cation, and the hydrogen content H_{10n} of the dopant comprises at least one increased binding energy hydrogen species.
260. A method according to claim 180, wherein said dopant having a formula $MSi_{4n}H_{10n}O_{n+1}$ wherein n is an integer, M is an alkali or alkaline earth cation, and the hydrogen content H_{10n} of the dopant comprises at least one increased binding energy hydrogen species.
261. A method according to claim 180, wherein said dopant having a formula $M_qSi_nH_mO_p$ wherein q, n, m, and p are integers, M is an alkali or alkaline earth cation, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.
262. A method according to claim 180, wherein said dopant having a formula $M_qSi_nH_m$ wherein q, n, and m are integers, M is an alkali or alkaline earth cation, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.

263. A method according to claim 180, wherein said dopant having a formula $Si_nH_mO_p$, wherein n, m, and p are integers, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.

264. A method according to claim 180, wherein said dopant having a formula Si_nH_m wherein n and m are integers, and the hydrogen content H_m of the dopant comprises at least one increased binding energy hydrogen species.

265. A method according to claim 180, wherein said dopant having a formula $MSiH_n$ wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

266. A method according to claim 180, wherein said dopant having a formula Si_2H_n wherein n is an integer from 1 to 8, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

267. A method according to claim 180, wherein said dopant having a formula SiH_n wherein n is an integer from 1 to 8, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

268. A method according to claim 180, wherein said dopant having a formula SiO_2H_n wherein n is an integer from 1 to 6, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

269. A method according to claim 180, wherein said dopant having a formula $MSiO_2H_n$ wherein n is an integer from 1 to 6, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

270. A method according to claim 180, wherein said dopant having a formula MSi_2H_n wherein n is an integer from 1 to 14, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

271. A method according to claim 180, wherein said dopant having a formula M_2SiH_n wherein n is an integer from 1 to 8, M is an alkali or alkaline earth cation, and the hydrogen content H_n of the dopant comprises at least one increased binding energy hydrogen species.

Add C1 >